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Contents

VII Preface
   Hennerici, M.G. (Mannheim)

1 Principles of Cerebral Ultrasound Contrast Imaging
   Powers, J. (Bothell, Wash.); Averkiou, M. (Nicosia)

11 Physical Principles of Microbubbles for Ultrasound Imaging and Therapy
   Stride, E. (London)

23 Ultrasound Bio-Effects and Safety Considerations
   ter Haar, G. (Sutton)

31 Intima-Media Thickness of Carotid Arteries
   Touboul, P.-J. (Paris)

40 Functional TCD: Regulation of Cerebral Hemodynamics – Cerebral Autoregulation, Vasomotor Reactivity, and Neurovascular Coupling
   Wolf, M.E. (Mannheim)

57 Intracranial Perfusion Imaging with Ultrasound
   Meairs, S.; Kern, R. (Mannheim)

71 Parenchymal Imaging in Movement Disorders
   Fernandes, R.C.L. (Rio de Janeiro); Berg, D. (Tübingen)

83 Sonothrombolysis
   Meairs, S. (Mannheim)

94 Non-Invasive Transcranial Brain Ablation with High-Intensity Focused Ultrasound
   Jenne, J.W. (Bremen)

106 Ultrasound-Induced Blood-Brain Barrier Opening for Drug Delivery
   Alonso, A. (Mannheim)

116 Author Index

117 Subject Index
Since the introduction of non-invasive ultrasound technologies in clinical practice in the early 1970s, the diagnosis and treatment of neurovascular diseases have made tremendous progress. Today, ultrasound is capable not only of monitoring the early silent stages of atherogenesis in infancy and atherosclerosis in very old age in an increasingly ageing population but also of identifying and evaluating the morphological patterns of plaque development and prognosis during progression and regression in most large arteries of the body. In addition, perfusion studies can be performed to assess arteriolar and capillary networks as well as collateral capacities in small vessel disease.

The ability of ultrasound to visualise both arterial and venous blood flow characteristics, including turbulence vortices and tortuosities, as well as vessel wall structures, thrombus formation and the generation of emboli during treatment or spontaneous fragmentation can be observed and quantified based on circulating microemboli. Translational studies have contributed to increasingly enormous knowledge about the underlying pathomechanisms and molecular biological processes. In line with other vascular imaging modalities, such as magnetic resonance angiography and computed tomography angiograms, vascular ultrasound studies are important tools in individual patients during follow-up. Indeed, ultrasound has become the stethoscope of the stroke physician and has widely replaced palpitation and auscultation in vascular medicine.

In addition, ultrasound has been implemented in prospective randomised clinical trials, both in epidemiological and in interventional studies. The standardisation of examination procedures and refined states of technology and data analysis has helped to identify new pathways for the best medical management of patients, e.g. lifestyle modification; treatment of the risk factors of atherosclerosis and thromboembolism; or interventional and surgical management, such as thrombectomies, stenting and dilatation. In addition, although not yet established in clinical practice, sonothrombolysis with or without drug application has made considerable progress. Catheter-based transcutaneous and intraarterial ultrasounds show enhancement of fibrinolytic agents, and in the early 20th century, the first clinical studies evaluated the adjunct effect of ultrasound in treating patients with acute ischaemic stroke, whether
frank insonation of large vessels or by microbubble-enhanced thrombolysis with or without encapsulated tissue plasminogen activator was used.

The transport of microbubbles incorporating other drugs has been tested and is currently being developed to pass through the intact blood-brain barrier (BBB) in specific focused areas, sometimes combined with other neuroimaging technologies for the treatment of non-vascular diseases. Apart from the temporary destruction of the BBB, the closure of vascular leakage may be useful in patients suffering from intracerebral haemorrhage. Increasing knowledge also suggests that ultrasound may be applied for transient focal opening or closure of the BBB if combined with high-resolution MR imaging of brain tissue to facilitate ‘microscopic’ treatment; with very limited tissue damage, minimally invasive permanent or transient tissue modulation may be achieved, as recently shown for the treatment of essential tremor, Parkinson's disease and other brain disorders.

Animal models and randomised clinical trials are important tools in translational studies, contributing to our increasing knowledge, and will be reviewed in several sections in this book. New developments in technology and imaging refinement will be addressed in addition to supportive technologies used for neurovascular studies; a separate chapter deals with potential bioeffects and safety issues. New aspects of structural and functional imaging will be addressed based on useful information from experimental studies, leading to refined assessment of healthy subjects and of patients with cerebrovascular and neurodegenerative diseases. Finally, recently developed strategies will be presented for non-invasive ultrasound treatment, which is still limited in clinical application but ready to undergo properly designed trial evaluation.

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